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(Easy, quick and cheap solutions are impossible, if semantics of CCIS are affected.)

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The Benefit of Ontologies for Interoperability of CCIS.

(Easy, quick and cheap solutions are impossible, if semantics of CCIS are affected.)

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Abstract

In spite of all efforts, it hardly succeeded to make Command and Control Information Systems (CCIS) semantical interoperable /1/. The harmonization of information systems is extremely expensive and in many cases it has hardly brought the expected improvements. Due to that another approach could ease the sophisticated situation. The information exchange can be supported by knowledge based linguistic algorithms, which analyse incoming information and convert it according to the required semantic boundary conditions of the target database. These algorithms base on ontologies, which are the formal description of concepts and relationships of objects that are relevant for a domain and describe, how we see the world we are looking at. No changes of the existing CCIS are necessary – they may remain as they are.

Harmonization is extremely difficult

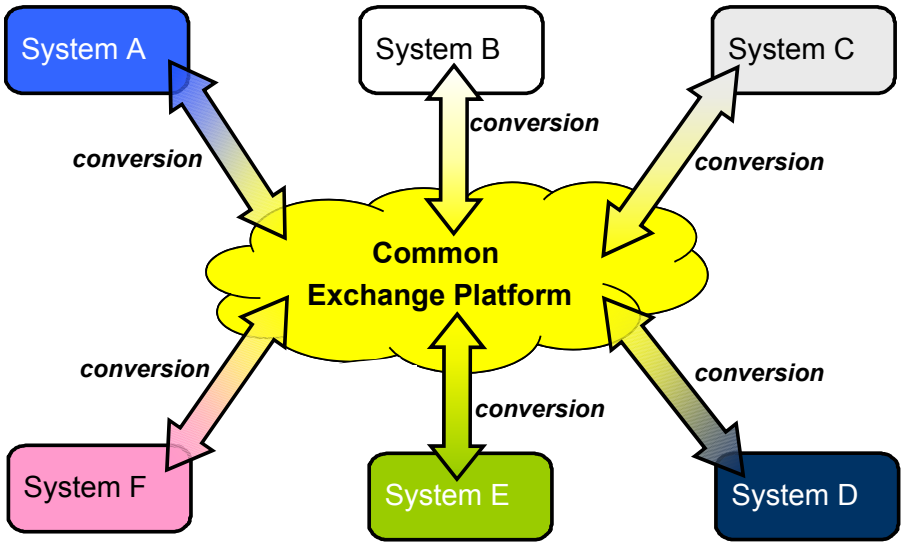
Many documents describe command and control information system architectures from NATO or national point of view. Most of them stress in all variations the necessity of a shared understanding of a common operational picture (COP). However, in all cases an overarching architecture requires the acceptance of harmonizations to enable an information exchange among heterogeneous systems or organizations. All the many concepts/approaches/ideas/philosophies are in some cases similar and in other cases different. But one particular lineament is valid for them all: they hardly become reality in all consequences.

Compared to civil business, the military situation is characterized through an extreme democratic conglomerate of parties with equal rights to require and refuse. In civil enterprises usually the headquarters determines the behaviour of the subsidiaries. In other cases de-facto standards (e.g. Microsoft Office), provided by dynamic entrepreneurs, harmonize the behaviour of independent individuals. These kinds of harmonizations occur in military situations only by fortunate coincidences.

Due to the enormous variety of existing techniques, requirements, political and factual constraints, the attempt to establish an overarching architecture even for partial solutions requires an enormous amount of time and effort. As an example, ATCCIS (Army Tactical Command and Control Information System) started in 1982 as a NATO interoperability study /2/. Today the concepts of ATCCIS are used in MIP (Multilateral Interoperability Programme) /3/ where nations can exchange some battlefield information automatically using their national CCIS systems. The exchanged data comply with a

commonly agreed semantic standard (Figure 1). For 2006, a fieldable solution is planned. Many technical, procedural and organisational questions are not solved yet. However, about 25 (!) years of

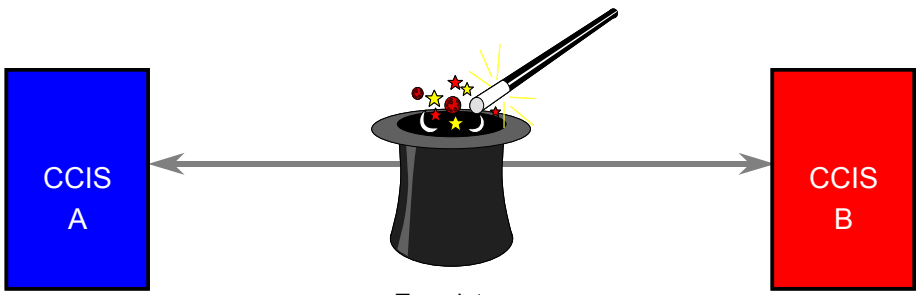
Figure 1: Common Exchange Platform



work are supposed to lead to a not sufficient but at least acceptable solution.

Nevertheless, ATCCIS and MIP are absolutely worth to be strongly supported. The benefit of both is the success in realizing interoperability by operating a common accepted semantical harmonization – which is a unique situation in military affairs. It took years to convince decision makers of the benefit of semantic logical data (exchange) models. And now the broad hesitation turns towards an effusive enthusiasm – which is problematic, too. Semantic harmonization is extremely complex and very expensive. Due to the variety and complexity of existing situations (involved organizations, multitude of decision makers, evolving techniques, …) a detailed technical migration path is very hard to describe. This is also valid for the assessment of the funding. Hence, the decision to establish interoperability via a semantic harmonization and the ex post modification of existing CCIS is extremely risky.

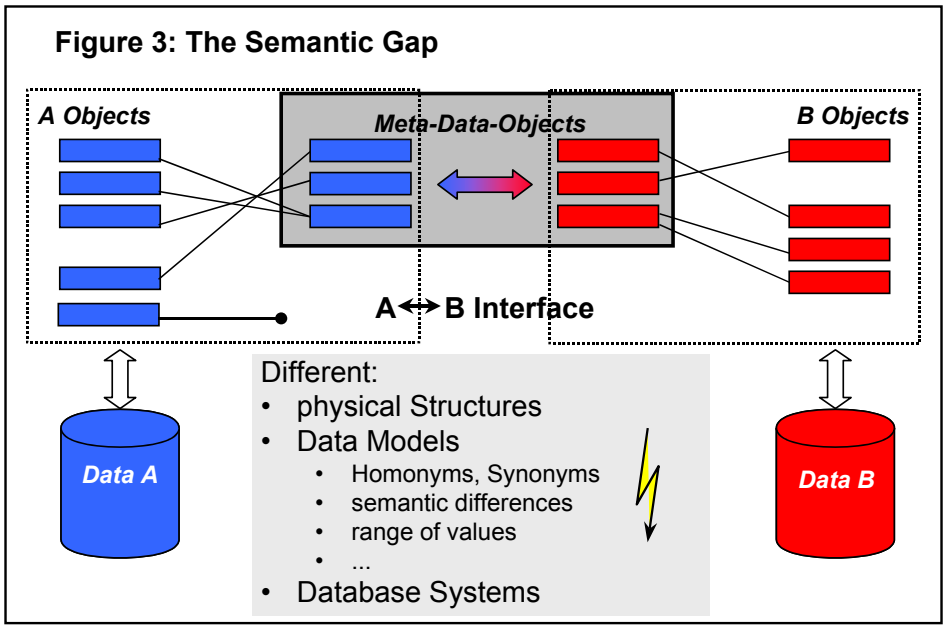
Figure 2: PowerPoint-Interoperability ?



Translator
Mediator
Interface
Interop.-Box
...

The required efforts to enable real interoperability of information systems are underestimated. Interoperability comprises two important aspects: the semantic and the technical one. The technical aspect is often emphasized whereas the semantic aspect has a shadowy existence. In many presentations and project plans a PowerPoint-interoperability (Figure 2) is shown – it is easy to draw a black box in between two systems, but it is hard to describe the intelligent operations inside of the box. The real problem to bridge the gap between the heterogeneous interpretations of data is not tackled (Figure 3). Several reasons may be responsible for this situation, but one fact is surely vivid: it is very burdensome to acquire detailed and funded knowledge about the operational processes and make process-, data- and functional modelling for both sides of the required interface. In addition it is hard to achieve but nevertheless necessary to incorporate experienced military personnel because these personalities usually are in charge for many other tasks. Over all it seems to be much more easier to realize any technical solution for an interface than to find a semantical satisfying solution.

Figure 3: The Semantic Gap



The above-mentioned drawbacks seem to describe a law of nature for information system development processes. Hence another approach to realize interoperability should be taken into account. In some cases occasional prerequisites are positive for the success of a harmonization process – then it should be done. In other cases it might not be reasonable to apply such a strategy.

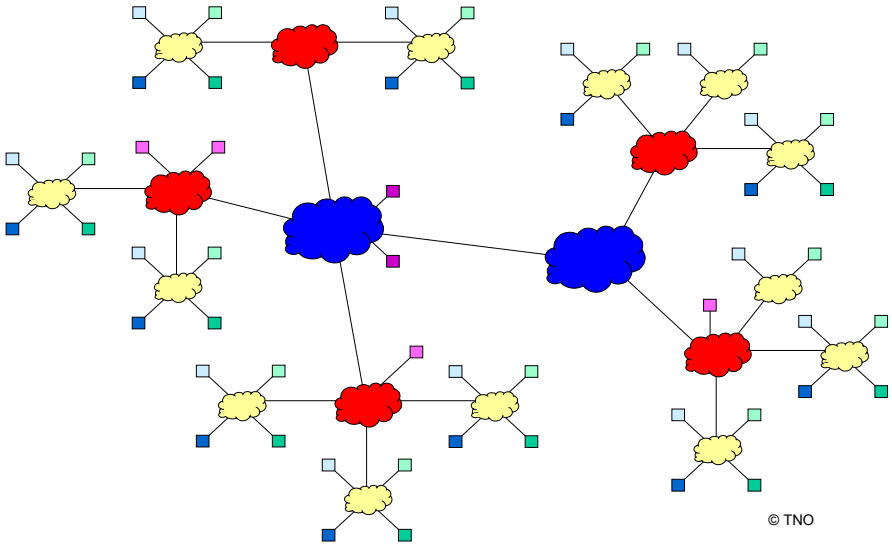
Examples

- Some navies use MCCIS as their CCIS and therefore they are interoperable among each other. The coincident that led to the actual situation might not be expectable for other situations. Maybe the participating decision makers – because of what circumstances ever – had fortuitously the same ideas, all legacy systems had to be replaced anyway, funding was ensured, a reasonable alternative (in this case: MCCIS) for a new CCIS was actually available etc.
- The solution for MIP is feasible for army battlefield requirements, but it might not be transferable to other branches. Obstacles could be: too big differences in the semantic models of the concerned CCIS or the inability to establish a consensus.

Which boundary conditions may ever exist, one thing is absolutely true: Easy, quick and cheap solutions are impossible, whenever semantics are affected. System development is the solidification of explicit and implicit operational knowledge in software. Different cultures, different general frameworks of organisations, different experiences, different needs of particular customers, different views and assumptions of the same facts of matter, and different phraseology, methods and structures lead to heterogeneous systems – and this is probably inevitable for information technology anyway. Common accepted and standardized procedures or semantic standards to avoid different structures are not in sight. This means, that the effort to work constantly against a "natural individual software development process" might be enormous and hopeless.

It is impossible to get the whole (military) world semantically standardized. At best we will have a situation of several areas with similar boundary conditions, where harmonization works (Figure 4). Information systems belonging to one of these domains of applicability might use an interface concept as shown in Figure 1. These domains can be e.g. "battlefield", "logistics" or "sanitary".

Figure 4: Several Domains



Alternative to Harmonization

But which solution is applicable when a common exchange platform is not available or a harmonization process is not enforceable? For such a purpose, an additional intelligent mechanism is required that allows the seamless information exchange between information systems that were not initially developed for this purpose. This mechanism must be able to interpret the meaning of the incoming information, filter the relevant data, convert it according to the semantical restrictions of the target CCIS, and store it in the database correctly. The heterogeneous CCIS remain unchanged – the software and the database of the systems remain like they are.

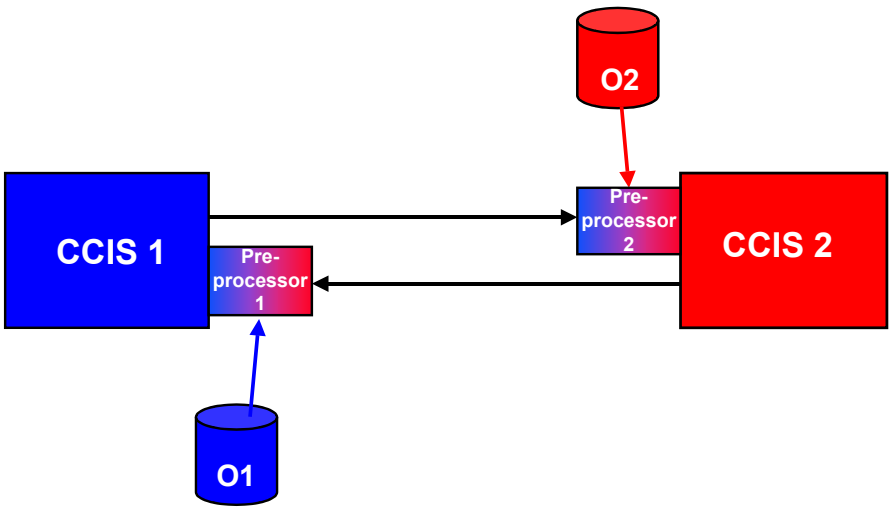
In many cases, liaison officers perform the interface between heterogeneous systems ("swivel chair"). They convert information of one system and feed the other one. Due to their experience, they own implicit knowledge about operational facts. If it is possible to represent explicitly the knowledge of a domain that usually experienced experts have implicitly, this reservoir could be the basic for the algorithm described above. This reservoir might be implemented in a shared ontology and be the key

tool for the interoperability of heterogeneous information systems. An ontology is a formal description of concepts and relationships of objects that are relevant for a domain /4/. It is similar to a common data model, but enriched with a set of semantic relations e.g. constraints, generalisation, specialisation, part-of, has-part). It describes, how we see the world we are looking at.

In a current project of our research institute we pursue the content extraction of free text messages concerning battlefield affairs /5/. A way to communicate with information systems is the usage of natural language texts. Messages according to standard-formats like ADat-P3 or arbitrary texts without any or weak formatting are used as input. The only precondition for information exchange is the selection of a particular language. Computer linguistic technologies – syntactical and semantical analysis – shall perform the content extraction and the storing of relevant data in the database of a CCIS.

The idea is to apply the linguistic techniques to the interoperability among heterogeneous CCIS. CCIS 1 could send an extract of its proprietary database to CCIS 2 (Figure 5). Here, a semantic pre-processor comprises an ontology-based mechanism that processes the incoming data and makes it suitable to the semantics of the target database.

Figure 5: Ontologies for Interoperability



The advantage of this approach is that existing systems remain unchanged and no expensive harmonization is required. Of course, nothing is for free. If any function of automated information processing is required, semantics play a role. But in some cases it might be easier and over all cheaper to allow CCIS being heterogeneous and dispatch information that do not comply with a commonly agreed semantic standard. The necessary harmonization can be limited to the introduction and use of ontologies, but the heterogeneous systems can remain as they are.

The first step is to build an ontology for a common view of the military domain, starting with a particular domain, the battlefield. The ontology bases on the ATCCIS data model /2/. The battlefield ontology must be used to extract the meaning of messages. Example: "The hostile tank stops in front of the obstacle". For a human being there is no question where "in front of" is, but an automatic system needs additional knowledge to decide on which side of the obstacle the hostile tank is. The ontology

provides this knowledge. It comprises not only attributed for "obstacle" (coordinates, kind, …), but also coherences and constraints /6/.

Conclusion

The main problem usually is not the technical conveyance of information: A communication can be established in an easy, quick and cheap way (eMail and MS-Word, HTTP and HTML etc.). XML or other syntax definitions can be used to format the messages. COTS products provide easy, quick and cheap solutions while an ontology-based process manages the semantical correct understanding of the information content for sender and receiver.

References

/1/ Wunder, M.: Multilateral Interoperability for Heterogeneous Army CCI Systems. In: Proceedings from the Oslo Symposium "Building a Vision – NATO's Future Transformation", NATO CDE Cell, Norfolk, Virginia, 2001.

/2/ ATCCIS WP 5-7, Edition 5.0: Overview of the Land C2 Information Exchange Data Model (LC2IEDM). NATO: ATCCIS PWG, 2002.

/3/ http://www.mip-site.org

/4/ Gruber, T.: A translation approach to portable ontologies. Knowledge Acquisition, 5(2): 199-220, 1993

/5/ Hecking, M.: Analysis of Spoken Input to C2 Systems. In: Proceedings of the 7th International C2 Research and Technology Symposium (ICCRTS), Quebec, Canada, 2002.

/6/ Schade, U.: Towards an Ontology for Army Battle C2 Systems; 8th International C2 Research and Technology Symposium (ICCRTS), Washington DC, 2003